



Notes on the geographic range and distribution of two free-tailed bat species (Chiroptera, Molossidae) in Costa Rica

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Abstract

Nyctinomops laticaudatus (É. Geoffroy St.-Hilaire, 1805) and *Eumops nanus* (Miller, 1900) are 2 species with distributions that are expected for Costa Rica. However, voucher specimens that confirm the presence of these species in the country are absent or missing in museum collections. Here we document voucher specimens and present data that confirm the presence of *N. laticaudatus* and *E. nanus* in Costa Rica.

Key words

Eumops nanus; *Nyctinomops laticaudatus*; Central America; new records.

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Introduction

The Molossidae are a family of medium-sized to large bats with about 16 genera and more than 100 species distributed worldwide (Simmons 2005, Eger 2008). The members of the family are characterized by the presence of long tails that project beyond the tail membrane or uropatagium (Emmons and Feer 1997, Reid 2009). Their common name, free-tailed bats, originates from this characteristic.

Despite growing information on the geographic distribution of free-tailed bat species in the Neotropics (e.g. Gregorin and Taddei 2000, Pineda et al. 2008, Baker et al. 2009, Bianconi et al. 2009, Feijó et al. 2010, Gregorin et al. 2011, Rodríguez-Herrera et al. 2014, Medina-Fitoria et al. 2015, González-Terrazas et al. 2016), there are still

many distributional gaps, creating the illusion that some of the species are rare, patchily distributed, or absent in some areas (Reid 2009). This rarity seems to be a direct consequence of the difficulty in capturing these bats with traditional methods, such as placing mist nets at ground level (Reid 2009), and more complex inventory techniques, such as acoustic recordings that are not always available to all tropical bat researchers. Moreover, many free-tailed bats possess complex and varied search call designs (Jung et al. 2014) that complicate their identification.

Some recent publications on free tailed bats from Costa Rica expand the distribution ranges of some (e.g. *Eumops hansae* (Sanborn, 1932), Pineda et al. 2008) or confirm the presence of other species (e.g. *Promops centralis* Thomas, 1915, Rodríguez-Herrera et al. 2014).

Despite that approximately 5 genera and 14 species of free-tailed bats have been reported for the country (Rodríguez-Herrera et al. 2014), Costa Rica still has several information gaps regarding the presence of some of them, mainly by the absence of direct evidence (i.e. voucher specimens). This is the case of some free-tailed bats of the genera *Nyctinomops* Miller, 1902 and *Eumops* Miller, 1906.

Nyctinomops includes 4 native species of America (Simmons 2005), the Peale's Free-tailed Bat, *N. aurispinosus* (Peale, 1848); the Pocketed Free-tailed Bat, *N. femorosaccus* (Merriam, 1889); the Broad-eared Bat, *N. laticaudatus* (É. Geoffroy St.-Hilaire, 1805), and the Big Free-tailed Bat, *N. macrotis* (Gray, 1840). With exception of *N. femorosaccus*, which has a restricted distribution in areas of Mexico and the United States (Kumirai and Jones 1990, Simmons 2005), the rest of species have been detected in northern and southern parts of the New World, suggesting that there are likely to occur in Central American countries such as Costa Rica. In particular, 1 of these 3 species, *N. laticaudatus*, has never been captured in Costa Rica despite indirect evidence that links the acoustic information collected by LaVal and Rodríguez-Herrera (2002), with its presence in Costa Rica in the Central Pacific Coast and Central Valley.

On the other hand, the genus *Eumops*, commonly known as bonneted bats, is a monophyletic New World group of 16 recognized and 1 undescribed species of free-tailed bats (Eger 1977, Koopman 1993, Gregorin and Taddei 2000, McDonough et al. 2008, Baker et al. 2009, Medina et al. 2014, Gregorin et al. 2016). The diversity of *Eumops* in Costa Rica presumably includes 5 species (Rodríguez-Herrera et al. 2014): the Underwood's Bonneted Bat, *Eumops underwoodi* (Goodwin, 1940), the Black Bonneted Bat, *Eumops auripendulus* (G. Shaw, 1800), the Fierce Bonneted Bat, *Eumops ferox* (Gundlach, 1861), the Sanborn's Bonneted Bat, *Eumops hansae*, and the Dwarf Bonneted Bat, *Eumops nanus* (Miller, 1900).

The presence of *E. nanus* in the Costa Rica is a controversial issue (Pineda et al. 2008). *Eumops nanus* was allegedly reported in the Pacific and Atlantic lowlands of the country by Rodríguez and Chinchilla (1996) on the basis of 3 voucher specimens deposited in the Museo de Zoología, Universidad de Costa Rica (UCR175, UCR515, and UCR785). Nevertheless, despite the intense search efforts made at the museum, the specimens were not found, which leads us to think that they have been lost (Pineda et al. 2008, this study).

Both, *N. laticaudatus* and *E. nanus*, has been repeatedly included and excluded from the literature of the country using several arguments (Janzen and Wilson 1983, Rodríguez and Chinchilla 1996, Timm and LaVal 1998, Rodríguez-Herrera and Wilson 1999, LaVal and Rodríguez-Herrera 2002, Rodríguez-Herrera et al. 2002, 2014); thus, in order to resolve this situation, we present voucher specimens and confirm the presence of *N. laticaudatus* and *E. nanus* in Costa Rica.

Methods

The specimens reported here came from 2 different localities of Costa Rica. The first was at Santa Ana canton, in the southwestern of the San José province, a specimen of *Nyctinomops laticaudatus* was found dead, at a medium level of decomposition, on the ground by two of us (AGQ and LLH). The site of collection is characterized by the presence of several forest patches surrounded by open areas dedicated to cattle, crops and human settlements, and shows an annual biotemperature and precipitation regimens of between 12–18 °C and 4,000–8,000 mm respectively (Holdridge 1967). The second locality was at Río Enmedio, Santa Cruz canton, in the northwestern Pacific lowlands of the Guanacaste province, where 4 individuals of *Eumops nanus* were captured by BRH and DVC at 2 independent times with mist nets set above the river (0.5 m depth). The capture site of the animals belongs to a governmental protected forested area and shows an annual biotemperature and precipitation regimens of between 24–30 °C and 2,000–4,000 mm respectively (Holdridge 1967).

Voucher specimens were collected with permissions from MINAET-SINAC (Resolución No. SINAC-SE-CUSBSE-PI-R-131-2016 and Resolución No. ACT-OR-DR-147-14). In the case of *E. nanus*, bats were sacrificed following the standards of the American Society of Mammalogy (Sikes et al. 2016). All specimens collected were fixed in 10% formalin and then preserved in 70% ethanol. The skull from 1 specimen per species was extracted and cleaned after fixation. Using a digital caliper, the following morphometric and cranial measurements were recorded following Freeman (1981): total length (ToL), tail length (TaL), ear length (EL), hind foot length (HFL), forearm length (LF), body mass (BM), greatest length of skull (GLS), zygomatic breadth (ZB), mastoid breadth (MB) and postorbital constriction (PC). Vouchers are deposited at the Mammal collection of the Museo de Zoología, Universidad de Costa Rica (UCR).

Results

Nyctinomops laticaudatus (É. Geoffroy St.-Hilaire, 1805) Figure 1

New record. Costa Rica: San José province: Santa Ana: Fila Cerros de Escazú (09.8849° N, 084.1881° W; 1778 m a.s.l., Fig. 1A), collected by AGQ and LLH, 24 February 2016 (1 specimen, adult female, voucher UCR 4687).

Identification. *Nyctinomops laticaudatus* differs from all other species of the genus potentially distributed in Costa Rica (i.e. *N. aurispinosus* and *N. macrotis*) in being overall smaller in several external and cranial measurements (Table 1). In the field, the length of the forearm is one of the most useful characters to identify species of *Nyctinomops* (Jones and Arroyo-Cabral 1990, Milner et al. 1990, Timm and LaVal 1998, Avila-Flores et al. 2002, Díaz et al. 2011), as *N. aurispinosus* and *N.*

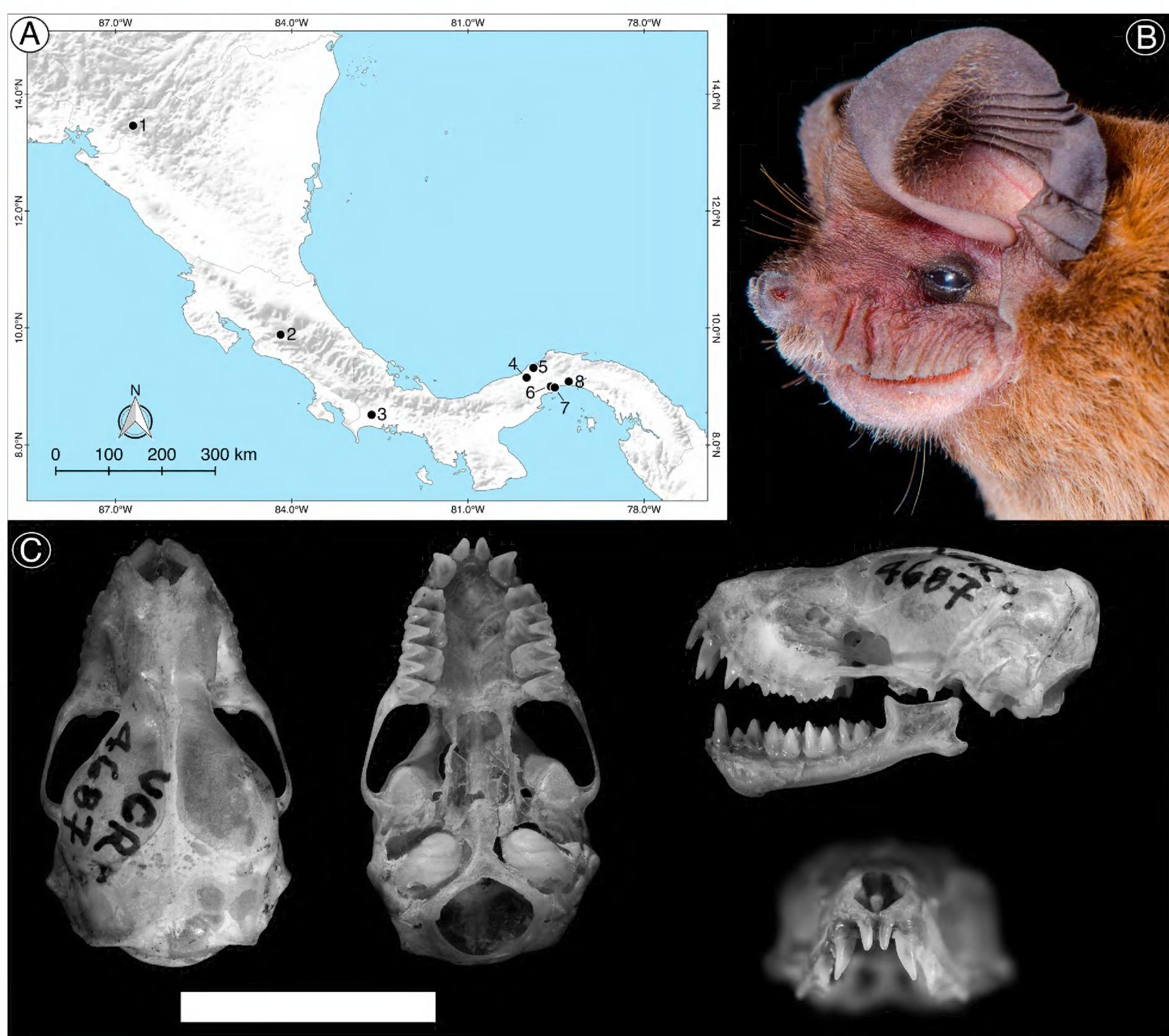


Figure 1. Geographical and morphological information of *Nyctinomops laticaudatus*. **A.** Localities of distribution of *N. laticaudatus* in Costa Rica and neighbouring countries: 1—Monumento Nacional Cañón de Somoto, Nicaragua (Medina-Fitoria et al. 2015); 2—new record: Fila Cerros de Escazú, Santa Ana, San José, Costa Rica; 3—La Concepción, Chiriquí, Panama (USNM336901); 4—Barro Colorado Island, Panama (MSB29058); 5—Fort Gulik, Colón, Panama (AMNH183873); 6—Miraflores, canal zone, Panama (USNM312115); 7—Panama city, Panama (USNM314570); 8—Pacora, Panama (USNM319141). **B.** Rostrum details of *N. laticaudatus* from an individual of Nicaragua. **C.** Dorsal, ventral, and lateral views of the skull, lateral view of the mandible and rostral view showing the upper incisors of *N. laticaudatus* (UCR 4687). Scale bar = 10 mm. USNM = National Museum of Natural History, Smithsonian Institution; MSB = Museum of Southwestern Biology, the University of New Mexico; AMNH = American Museum of Natural History. Image A and C by DVC, image B by José G. Martínez-Fonseca.

Table 1. Selected external and cranial measurements of *Nyctinomops laticaudatus* and *Eumops nanus* specimens from Costa Rica. *n* = sample size.

Morphometric measures (mm)	<i>N. laticaudatus</i> (n = 1)	<i>E. nanus</i> (n = 3)
ToL	95	85.83 ± 1.42
TaL	40	32.16 ± 0.72
EL	18	16.05 ± 0.28
HFL	9	7.50 ± 0.50
FL	41	39.03 ± 0.46
BM (g)	10.91	7.77 ± 0.33
Cranial measurements (mm)	<i>N. laticaudatus</i> (n=1)	<i>E. nanus</i> (n=1)
GLS	15.64	14.68
ZB	9.25	8.55
MB	9.07	8.57
PC	3.29	3.32

macrotis have longer forearms (≥ 47 mm and ≥ 54 mm, respectively) compared with *N. laticaudatus* (≤ 45 mm). In comparison with other similar species in terms of size and external morphology (for example *T. brasiliensis*) some distinguishing characters such as the ears joined at base, extended beyond the tip of the snout when laid forward, and the upper incisors parallel to each other, confirms the identity of our specimens as *N. laticaudatus* and not *Tadarida brasiliensis* (Fig. 1B, 1C).

Eumops nanus (Miller, 1900)

Figure 2

New record. Costa Rica: Guanacaste province: Santa Cruz: Río Enmedio at Parque Nacional Diriá (10.1738° N, 085.5961° W; 1778 m a.s.l., Fig. 2A), collected by

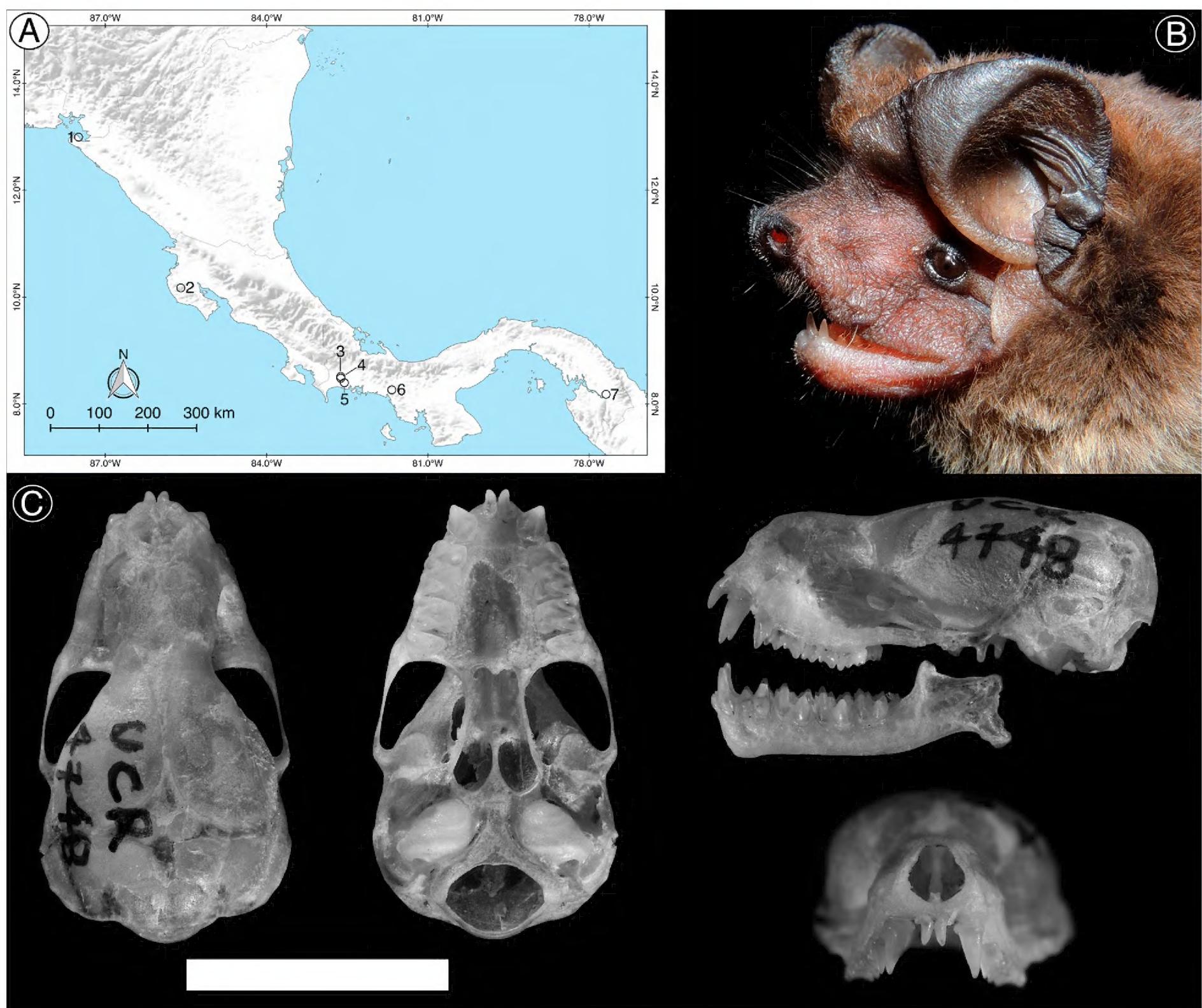


Figure 2. Geographical and morphological information of *Eumops nanus*. **A.** Localities of distribution of *E. nanus* in Costa Rica and neighbouring countries: 1–Potosí, Chinandega, Nicaragua (KU114142); 2–new record: Río Enmedio, Parque Nacional Diriá, Santa Cruz, Guanacaste, Costa Rica. 3–Boquerón, Chiriquí, Panama (Handley 1966); 4–Bugaba (Bogavo), Chiriquí, Panama (Handley 1966); 5–Alanje, Chiriquí, Panama (Dolan and Carter 1979); 6–Tolé, Veraguas, Chiriquí, Panama (Eger 1977); 7–Yaviza, Darién, Panama (MVZ136051). **B.** Rostrum details of *E. nanus* from an individual of Costa Rica. **C.** Dorsal, ventral, and lateral views of the skull, lateral view of the mandible and rostral view showing the upper incisors of *E. nanus* (UCR 4748). Scale bar = 10 mm. KU = University of Kansas Natural History Museum; MVZ = Museum of Vertebrate Zoology, UC Berkeley. Images A, B and C by DVC.

BRH and DVC, 8 April 2011 and 22 March 2015 (3 specimens, 2 adult males and 1 adult female, vouchers UCR 4748, UCR4095 and UCR 4749, respectively).

Identification. When comparing *E. nanus* with other bonneted bat species from Costa Rica (except *E. hansae* which overlaps in some characteristics), this species can be recognized by its smaller size in several external and cranial measurements (Table 1). Live animals can be distinguish from other species of *Eumops* by smaller measurements of body length, forearm length and body mass (Eger 1977, Timm and LaVal 1998, LaVal and Rodríguez-Herrera 2002, Reid 2009).

Despite that when specimens of *E. nanus* and *E. hansae* from Costa Rica are directly compared the first is usually smaller, a combination of several external and cranial characters are needed to confidently separate and identify the live as well as the museum specimens. For example, the fur is long (5 mm), pale, and whitish at the

base in *E. nanus*, while *E. hansae* have a relatively short fur (2–3 mm) and hairs are dark at the base (Eger 1977, Reid 2009) (Fig. 2B). The presence of few short hairs along the edge of the calcar in *E. nanus* and their absence in *E. hansae* also separate these species (Reid 2009). Cranial and tooth morphology are also useful to compare these species. In *E. nanus* the skull is nearly flat when viewed laterally (Fig. 2C), while the skull of *E. hansae* is more bulbous (Pineda et al. 2008). Moreover, the tips of the upper incisors of *E. nanus* are distally convergent and somewhat procumbent (Fig. 2C), contrary to the widely separated tips and slightly recurved inward upper incisors of *E. hansae* (Pineda et al. 2008).

Discussion

Our findings confirm the assumptions of several authors regarding the presence of these 2 free-tailed bat species

in Costa Rica (Koopman 1993, Rodríguez and Chinchilla 1996, Timm and LaVal 1998, LaVal and Rodríguez-Herrera 2002, Pineda et al. 2008).

Our observations corroborate that, in Costa Rica, *N. laticaudatus* can be found at middle elevations in the Central valley and in disturbed habitats that are not necessarily protected. Based on this observation, we concur with LaVal and Rodríguez-Herrera (2002) who predicted that the *N. laticaudatus* is expected to inhabit in several types of habitats with a wide range of altitudinal variation (between 0–1,800 m a.s.l.). Moreover, this record helps to close the distribution gap of *N. laticaudatus* in Central America. Our new record is about 489 km from the closest known locality in Nicaragua and by 231 km from the closest known locality in Panama (Fig. 1A).

The absence of Rodríguez and Chinchilla's (1996) voucher specimens of *E. nanus* and the lack of other evidence such as photographs of diagnostic characteristics of the species preclude us from accepting their report of this species in Costa Rica. There is the possibility of a misidentification by Rodríguez and Chinchilla (1996) because the *E. nanus* bat is easily confused with *E. hansae* as well as with other free-tailed bats such as *N. laticaudatus* or the Brazilian Free-tailed Bat, *Tadarida brasiliensis* (I. Geoffroy, 1824) (Pineda et al. 2008, Reid 2009). Based on this, our findings constitute the first confirmed record of *E. nanus* for the country, filling a distribution gap of *E. nanus* in Central America. Our record is approximately 379 km from the closest known locality in Nicaragua, and by 380 km from the closest known locality in Panama (Fig. 2A).

Finally, based on the mammal list published by Rodríguez-Herrera et al. (2014) and other recent publications related to this topic (Ramírez-Fernández et al. 2015, Villalobos-Chaves et al. 2016, Woodman and Timm 2016), our results increase the total number of living mammals of Costa Rica to 253 species and to 115 the total number of bats species. These discoveries also show that despite that the order Chiroptera is considered a well-studied mammal group in the country, the most basic aspects of species biology such as geographic distribution and natural history are still unknown for many species of small mammals, mainly bats and rodents. This highlights the need for more field work and research to improve our knowledge of the ecology of these poorly known mammal species.

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Authors' Contributions

BRH, DVC, AGQ and LRH collected the data; BRH and DVC identified the specimens; DVC and BRH wrote the text.

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